Williams Lake TSA inventory audit

Introduction

The Ministry of Forests conducts an inventory of each timber supply area (TSA) in British Columbia every 10 to 30 years—using standards and procedures developed by the Resources Inventory Program. Regular updates are undertaken to reflect changes in the timber volume due to growth and to depletions from harvesting and natural causes.

This report presents the results of an inventory audit performed within the Williams Lake TSA, which is located between Wells Gray Provincial Park in the east and Tweedsmuir Provincial Park in the west. The TSA is centred on the community of Williams Lake and covers 4.87 million hectares. It is administered by the Chilcotin, Williams Lake, and Horsefly Forest Districts.

Purpose of the audit and application of the results

It is often asked, "How accurate is the current inventory?" To answer this important question, the Ministry of Forests has developed an inventory audit methodology specifically designed to test the overall accuracy of estimates of the total standing volume in each timber supply area.

This inventory audit methodology entails sampling three primary components of the inventory: mature forests, immature forests, and non-forest areas.

The objective of the inventory audit program is to help identify TFLs or TSAs where the forest inventory needs attention. Enough samples are taken to ensure statistically reliable results for the TSA as a whole.

The amount of data collected, however, is not sufficient to make statistically reliable conclusions about specific areas or tree species. For example, any overall differences highlighted by the audit could result from problems with one tree species, from part of the land base (such as high elevation rather than lower elevation areas), from one age group of forest stands, or from a combination of these and other factors. As a consequence, general audit results cannot appropriately be used to adjust information about the forests currently available for timber harvesting since this area constitutes only a portion of the total forested area in the TSA.

The audits provide information that may be useful to the Chief Forester when determining the allowable annual cut—offering a general assessment of the uncertainty associated with mature timber volumes, immature site index, and the non-forest classification. However, the audit results cannot justifiably be used to make specific adjustments to growth and yield and other information used in timber supply analyses and allowable annual cut determinations.

Methods

Current inventory

There are 37 TSAs in British Columbia, varying in size from approximately 70 000 hectares to 13 million hectares. Inventories of each TSA are conducted through a multistage process. Polygons are first delineated from 1:15 000-scale aerial photographs. Photo-interpretation is then used to produce data on a number of attributes for each polygon. These attributes include species composition, stand height, age, and crown closure. Timber volume is then estimated indirectly using the photo-interpreted variables and an empirical yield model.

To keep estimates current, inventories are regularly updated to account for forest growth and for depletions due to harvesting, fire, and the impact of insects and disease damage. Empirical yield models, such as the Ministry of Forests Variable Density Yield Prediction (VDYP) computer model, are used to update the inventory for forest growth. Field visitation, satellite imagery, and aerial photographs may be used to update the inventory for depletions.

Inventory audit procedures

The inventory audit tests three components of the current inventory. The first component is the mature forested areas (forest stands older than 60 years). The inventory audit tests the accuracy of the mature timber volume. The second component tested is immature stands (younger than 60 years but older than the silvicultural classification of free growing). The audit tests the accuracy of the site growth potential (site index) assignment for these stands. The third component tested is the area classified as non-forest in the inventory, which includes areas such as lakes, gravel pits, and alpine meadows. The audit tests the accuracy of the photo-interpreted classification for this component.

Mature component assessment criteria

To test the mature component of the inventory, the existing inventory's estimate of the mean mature volume per hectare

for the TSA (*the inventory volume*), is compared with a new estimate of the mean mature volume per hectare obtained from the audit samples (*the audit volume*).

The difference between these two estimates is called the total bias. A test is conducted on this bias to determine if it is statistically significant. This test establishes whether there are detectable differences between the audit volume estimate and the inventory volume estimate, for the total forested area of the TSA.

If the total bias is found to be statistically significant, further analyses are conducted to determine if the specific source of bias within the inventory is one of the following:

- *classification bias:* This is caused by incorrectly estimating the polygon attributes; or
- *model bias:* This is caused by poor prediction from the yield model, which was developed for large areas of the province and was not designed for specific management units.

The analysis to determine the source of bias uses an estimate of the mean mature volume per hectare for the TSA called the *ground attribute volume*. This is calculated from audit sample attributes (stock and stand table estimates of species composition and stocking, and ground-based averages of top height and age), along with crown closure taken from the original map label, using the yield prediction model. The difference between the ground attribute volume estimate and the audit volume estimate approximates the bias associated with the yield model. The difference between the audit volume estimate and the inventory volume estimate not accounted for by the model bias approximates the bias associated with the inventory classification attributes. Once the source is identified, further analyses may be done on the inventory classification attributes or the yield model itself.

Immature component assessment criteria

Accuracy of the inventory classification for immature stands is tested by examining the site index assignment. Since the immature forest stand site index provides an estimate of site productivity, its accuracy affects the projection of long-term harvest levels.

Data gathered is examined to determine how closely the audit and inventory site indices match for individual samples, and to explore potential trends.

Non-forest component assessment criteria

The audit test for the non-forest component of the inventory assesses the accuracy of the non-forest classification assignment. An airphoto interpreter certified by the Ministry of Forests compares the non-forest inventory classification to a suitably-scaled forest cover aerial photograph. Classification accuracy is rated using a point scoring scheme to determine an overall accuracy percentage. The acceptance criteria for this test is 85% or higher.

Williams Lake TSA audit sampling procedures

The Williams Lake TSA sample used updated maps based on an inventory originally conducted between 1975 and 1992. A list of all polygons identified on the inventory maps was produced and sorted on a number of stand characteristics (site quality, age, and species group). Polygons were systematically selected from this list by a process designed to produce a representative sample.

For the mature forested component of the inventory audit, a random sample of 50 forested polygons from the total forested area in the TSA was selected for sampling.

Up to 4 full-measure prism plots and 5 count plots were established within each of the 50 sample polygons. The plots were located systematically, using a square grid and a random start point. The grid interval varied with polygon size. To reduce sample costs for large or irregular polygons, only a randomly selected portion of the polygon was sampled. A total of about 200 full-measure and 250 count plots were established. Field data collection and compilation followed Ministry of Forests cruising and cruise compilation procedures. The objective was to obtain audit volumes that were comparable (in terms of utilization standards and merchantability definitions) to the inventory volumes produced from the VDYP computer yield model.

The VDYP system produces net merchantable volume per hectare defined as stem volume inside bark of all live trees excluding a 10-cm diameter inside-bark top, a 30-cm-high stump, and decay (as estimated from Ministry loss factors). Dead potential and veteran trees are not included in the VDYP estimates. This volume is calculated for a utilization standard defined as all live trees of 12.5+ cm dbh. When considering the audit results, it should be noted that there are some differences between the utilization standards applied in the audit and those used operationally.

The audit volume estimates were then compared to the inventory volume estimates (from VDYP) to test the validity of the current inventory. A paired sample *t*-test was used to test for significant differences. The precision of the inventory volume estimates—how well each inventory volume estimate corresponds to the audit volume estimate on a sample-by-sample basis—was assessed by measuring the statistical correlation. The data was then post-stratified to detect trends related to the operable and inoperable forested land base distribution of the sampled polygons.

From the immature forested component, a random sample of 18 polygons was selected for sampling. Up to 6 inventory ground calls were established within each of the 18 sample polygons.

The plots were located along a single transect line that was considered representative of the site productivity (site index) of the stand. A total of about 108 ground calls were established and data collection followed the standard Ministry of Forests inventory ground call procedures. The location of the sample transect was subjective.

To audit the non-forest component, a random sample of 30 non-forest polygons was selected. Standard Ministry of Forests inventory airphoto classification techniques were used to compare the 30 non-forest polygon classification assignments to corresponding airphoto checks.

Inventory audit results

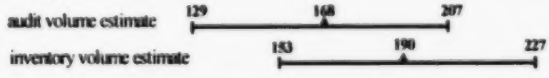
Analysis of mature volumes

Overall results of the inventory audit for mature volume in the total forested area of the Williams Lake TSA are summarized at the 12.5+ cm dbh utilization limit in Table 1.

TABLE 1: Statistics for the audit volume and inventory volume estimates at 12.5+ cm dbh utilization (net decay), for this regional sample in the Williams Lake TSA

	Audit volume estimate	Inventory volume estimate
Number of samples	50	50
Mean (m^3/ha)	168	190
Coefficient of variation (%)	82	68
Standard error	19.6	18.4
Sampling error (%)	23.4	19.4
95% confidence interval	129–207	153–227
Correlation coefficient		r = 0.795
Ratio of means (audit/inventory):		0.88

Bar graph representation of 95% confidence intervals (in m^3/ha):



The correlation coefficient of 0.795 for the audit and inventory estimates indicates a strong relationship among the individual samples in this stratum. There is a 22 m^3/ha difference between the mean inventory estimate for mature volume (190 m^3/ha) and the audit estimate (168 m^3/ha). A paired-sample t-test could not detect a statistically significant difference, 19 times out of 20. The 95% confidence interval for the mean paired difference is -46 to +3 m^3/ha.

Since there is no statistical difference between the two estimates, the ground attribute volume was not calculated.

It is important to note that the sampling error associated with the audit and inventory estimates of mean volume for this sample was substantially higher than the standard maximum acceptable level of 15%.

Analysis of operable and inoperable volumes

To provide audit results more likely to be applicable to the timber supply planning process, an approximation was made of the forested areas considered currently available for timber harvesting (operable areas). The audit results were post-stratified based on this approximation. However, since all 50 samples were found to be within the operable forested area, the results presented in Table 1 are identical for the operable forested area.

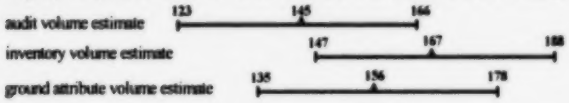
Analysis of mature volumes including the additional 1997 samples

Due to the large sampling error associated with the mature component volume estimates in the 1995 audit sample, an additional 74 mature polygons in the Williams Lake TSA were sampled to ensure that the variability of the volumes estimates was within acceptable levels. Polygons were sorted by the same criteria as for the original study and a systematic sample of 74 additional polygons were selected for sampling in the 1997 field season. The results from these additional 74 samples were combined with the 50 samples from the initial audit to form an enlarged audit of 124 samples. The results of the statistical analysis of the enlarged audit for the mature component of the total forested area are shown in Table 2 below. Note that all of the 124 samples were within the operable forested area of the TSA.

TABLE 2. Statistics for the audit volume, inventory volume, and ground attribute volume estimates at 12.5+ cm dbh utilization (net decay), for the enlarged audit sample in the Williams Lake TSA

	Audit volume estimate	Inventory volume estimate	Ground attrib. volume estimate
Number of samples	124	124	123
Mean (m^3/ha)	145	167	156
Coefficient of variation (%)	83	68	77
Standard error	10.8	10.3	10.9
Sampling error (%)	14.8	12.2	13.8
95% confidence interval	123–166	147–188	135–178
Correlation coefficient		r = 0.728	
Ratio of means (audit/inventory):		0.87	

Bar graph representation of 95% confidence intervals (in m^3/ha):



For the 124 samples in the mature component of the total forested area in the Williams Lake TSA, the mean audit volume is 145 m^3/ha and mean inventory volume is 167 m^3/ha. The difference of 22 m^3/ha between the two estimates was statistically significant 19 times out of 20.

Since there is a statistically significant difference between the two estimates, the ground attribute volume was calculated using the VDYP model. Top height was not available for one sample; therefore the ground attribute volume estimates are based on 123 samples. The estimated mean ground attribute volume is 156 m^3/ha.

The difference between the mean ground attribute volume (156 m^3/ha) and the mean audit volume (145 m^3/ha) is 11 m^3/ha . The difference between the mean inventory volume and the mean ground attribute volume is 11 m^3/ha. This suggests that the total bias in the inventory is associated with both the VDYP model and the inventory attributes in roughly the same proportion.

Analysis of immature inventory classification

Out of 18 stands sampled in the field, the inventory correctly identified site index within ±3 m of the audit site index for 5 stands; the inventory site index was more than 3 m lower than the audit site index for 8 stands, and more than 3 m higher for 5 stands.

Analysis of non-forest inventory classification

Thirty stands classified as non-forest were assessed for accuracy of the inventory. The resulting score was 87.5%, which meets the provincial minimum standard of 85%.

Discussion and conclusions

The objective of the inventory audit in the Williams Lake TSA was to assess the overall accuracy of the current (1975 to 1992) Ministry of Forests inventory. The mature, immature, and non-forest components were tested.

The results of the initial audit for the mature forested component of the inventory suggested that the inventory was statistically acceptable. However, the sampling error associated with the initial audit sample was higher than the maximum acceptable level of 15%.

To ensure that the variability associated with the volume estimates was within acceptable levels, an additional 74 samples were taken in the Williams Lake TSA and combined with the initial 50 audit samples. Analysis of the resulting 124 samples indicated that the inventory volume is overestimated. Since post-stratification indicated that all of the samples were operable, the analysis would also indicate that mature volume is overestimated in the operable forested area of the Williams Lake TSA. The bias in the inventory volume estimates appears to be associated almost equally with the VDYP model and the inventory classification attributes. Further analysis of the inventory bias observed in the Williams Lake TSA is currently being undertaken. A new vegetation inventory is also in process in this TSA and is scheduled for completion in the next several years.

Audit results for the immature component of the inventory suggest that it may not be accurate in site index assessment for young stands. The results would suggest that site index may be underestimated in the immature component of the inventory. These potential trends are being investigated by Regional staff.

The audit assessment of the non-forest classification in this TSA found it to be within provincial standards.

Glossary

accuracy: A measure of how close an estimate is to the true value.

allowable annual cut: The rate of timber harvesting specified for an area of land.

analysis unit: The basic building blocks around which inventory data and other information are organized for use in forest planning models, typically involving specific tree species or type groups that are further defined by site class, geographic

location or similarity of management regimes.

bias: The quality of a measurement device or procedures that tends to result in a systematic misrepresentation of what is being measured.

coefficient of variation: A relative measure of variation within a population, calculated as the ratio between the standard deviation and the mean value.

confidence interval: The range of values within which the population parameter is expected to lie.

confidence level: The estimated probability that a population parameter lies within a given confidence interval.

correlation coefficient: A measure of the relationship between two variables. A value of 0 for the correlation coefficient indicates a random relationship, whereas a value of ±1 indicates a perfect positive or negative linear correspondence.

dead potential trees: Standing or down dead timber which is estimated to contain at least 50% of its original gross volume in sound wood.

diameter at breast height (dbh): The stem diameter (outside-bark) of a tree measured at breast height (1.3 metres above the point of germination) to the nearest millimetre.

field visitations: Ground-level field procedures designed to provide physical verification of polygon inventory attributes.

free-growing (crop): A crop of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs, or other trees.

inoperable lands: Lands that are unsuited for timber production now and in the foreseeable future because of their topography, inaccessible location, low value of timber stands, or designation for uses incompatible with timber production.

mean: The average value of a set of observations.

polygon: A portion of land area, delineated on mid-scale aerial photographs, of "like" or uniform land cover type.

pre-inventory assessments: Inventory activities to evaluate the existing forest inventory as a basis for deciding whether to re-inventory or update the current inventory, and to document the existing inventory, maps, and photos to support the execution of the reinventory or update if required.

public sustained yield units (PSYU): A portion of a TSA; an area of Crown land, usually a natural topographic unit determined by drainage areas, managed for sustained yield by the Crown through the Ministry of Forests. It includes all Crown lands within the currently established boundaries of the unit and excludes federal lands, provincial parks, experimental forest reserves, gazetted watersheds and tree farm licences.

ratio estimate: The ratio between two different estimates.

representative: The quality of a sample having the same characteristics as the population from which it is selected.

sampling: The process of selecting observations.

sampling error: The error attributed to sampling procedures.

significant difference: The results of a statistical test comparing either two or more estimates, or an estimate to a fixed value. If the difference is too large to be attributed to chance, the difference is said to be statistically significant.

site index: An expression of the forest site quality of a stand, at a specified age, based either on the site height, or on the top height, which is a more objective measure.

standard error: An expression of the absolute variability of an estimate.

standard deviation: A measure of the variation of the population.

timber supply analysis: An assessment of future timber supplies over long planning horizons (more than 200 years) by using timber supply models for different scenarios identified in the planning process.

timber supply area (TSA): An area defined by an established pattern of wood flow from management units to the primary timber-using industries.

tree farm licence (TFL): Privately managed Sustained Yield Units; designed to enable owners of Crown-granted forest lands and old temporary tenures or the timber licences which replace them, to combine these with enough unencumbered Crown land to form self-contained sustained yield management units.

variable density yield prediction (VDYP) model: An empirical yield-prediction system for natural stands based on data collected in temporary inventory sample plots (TSPs) and natural, permanent growth sample plots (PSPs). VDYP predicts volume (net decay) and diameters at four utilization levels using stand height, age, and density. The aerial approach uses crown closure as the density measure.

veteran trees: Mature living trees which are remnants of an older stand.

For more information

For more information or to obtain other inventory audit reports, contact: Director, Resources Inventory Branch, 722 Johnson Street, Victoria, B.C., Canada V8W 3E7, Phone 250-387-1314, fax 250-387-5999, or visit our web site at http://www.for.gov.bc.ca/resinv/homepage.htm

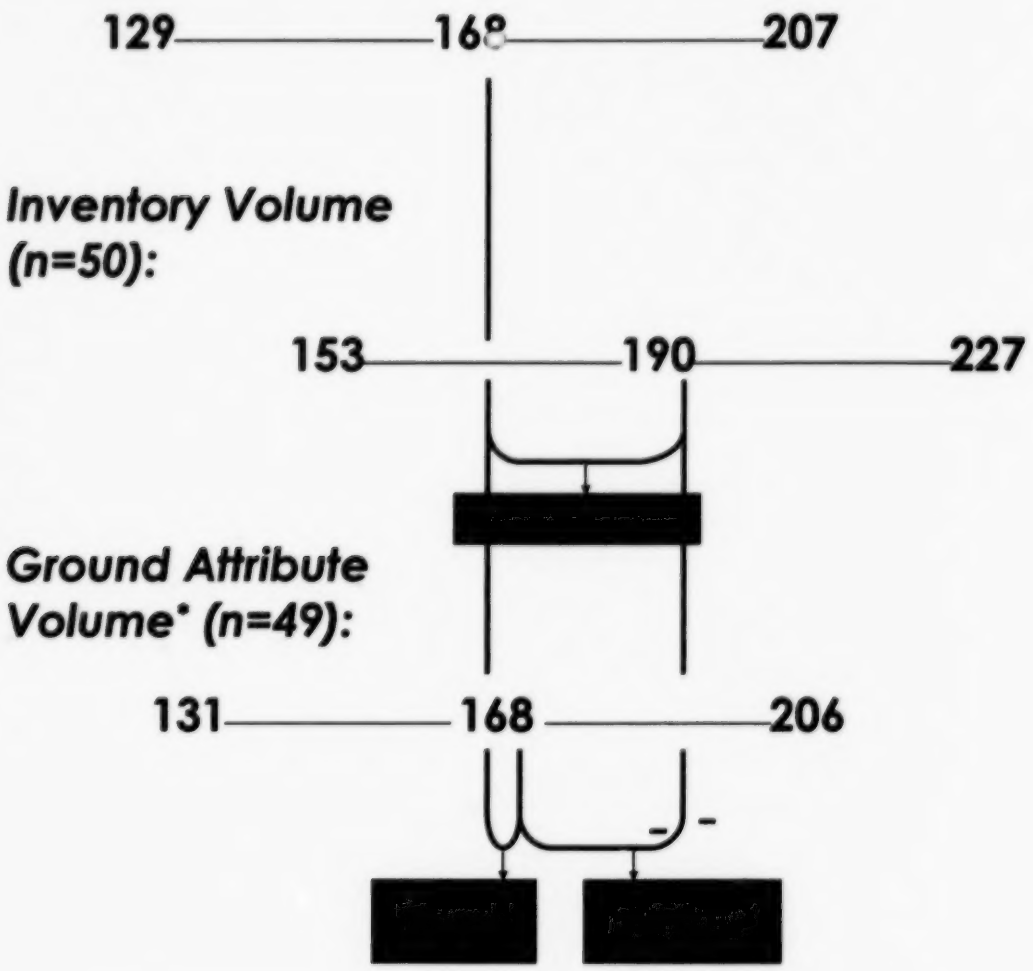
Inventory Audit Results : Overview Williams Lake TSA March, 1998

Study #1
- *Summary results* 2
- *Total bias* 3
- *"Model" bias* 5
- *"Attribute" bias* 7
- *Audit height vs. Inventory height* 9
- *Audit age vs. Inventory age* 11
- *Total bias excluding plots crew judged as "outside polygon"* 13
- *Mature Classification Assessment* 15

Study #2
- *Summary results* 16
- *Total bias* 17
- *"Model" bias* 19
- *"Attribute" bias* 21
- *Audit height vs. Inventory height* 23
- *Audit age vs. Inventory age* 25
- *Total bias excluding plots crew judged as "outside polygon"* 27
- *Mature Classification Assessment* 29

Study #1 & #2 combined
- *Summary results* 30
- *Total bias* 31
- *"Model" bias* 33
- *"Attribute" bias* 35
- *Audit height vs. Inventory height* 37
- *Audit age vs. Inventory age* 39
- *Total bias excluding plots crew judged as "outside polygon"* 41
- *Mature Classification Assessment* 43

Williams Lake TSA: Study #1



* "Ground attribute" volume is calculated from audit sample attributes (i.e. "ground" attributes: stock and stand table estimates of species composition and stocking, and ground-based averages of top height and age), along with crown closure taken from the original map label, using the VDYP yield prediction model. The difference between the ground attribute volume estimate and the audit volume estimate *approximates* the bias associated with the yield model. The difference between the ground attribute volume estimate and the inventory volume estimate *approximates* the bias associated with the inventory classification attributes. These two bias components comprise the *total bias* in the inventory. Note that top height and age was not available for sample #108 hence mean ground attribute volume is based on 49 samples.

Study #1

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) (n=50)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Kozak/Tree Class 1,2)*

129——————**168**——————**207** Audit Volume
(23.4% sampling error)

153——————**190**——————**227**
Inventory Volume
(map label attributes predicted in VDYP)
(19.4% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$R =$ *average audit volume* $= 0.88$
average inventory volume

1.0
↓
0.76——————**0.88**——————**1.01**

• *Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the audit volume and the inventory volume.*

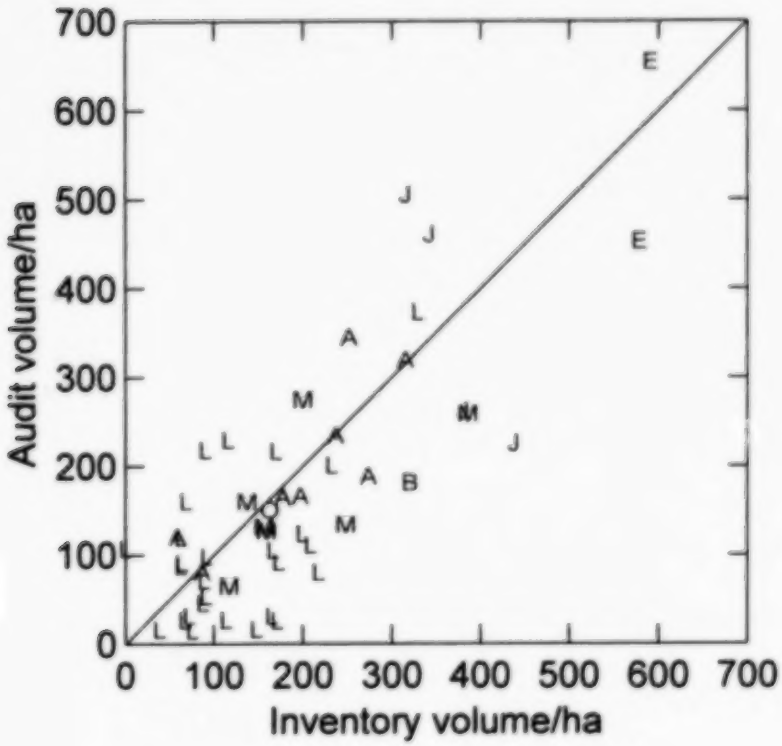
3. Paired T Test @ 95% (α=0.05) for all sample polygons
mean difference = -21.91 m^3/ha
p - value for mean difference = 0.079
since p-value > α, the difference is not significant

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were no significant differences within any of the GTGs.

5. Correlation @ 95% (α=0.05) for all samples
Correlation co-efficient $r = 0.795$
p value for correlation co-efficient < 0.001
.: correlation is significant

Williams Lake TSA Inventory Audit Study #1: Audit Volume vs. Inventory Volume (by GTG)

(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #1

Audit Volume (Kozak) vs. Ground Attribute Volume (Predicted in VDYP): "VDYP model" bias (n=49)*

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Kozak/Tree class 1,2))*

126——————**166**——————**206** Audit Volume (n=49) (24.0% sampling error)

131——————**168**——————**206** Ground Attribute Volume (predicted in VDYP) (n=49) (22.4% sampling error)

2. Ratio Analysis : Ratio of Means @95% (n=49)

$$R = \frac{\text{average audit volume}}{\text{average ground attribute volume predicted in VDYP}} = 0.99$$

1.0
↓

0.87——————**0.99**——————**1.10**

* *Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the audit volume and the ground attribute volume.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons (n=49)
   mean difference = -2.48 m^3/ha
   p - value for mean difference = 0.795
   **since p - value > α, the difference is not significant*

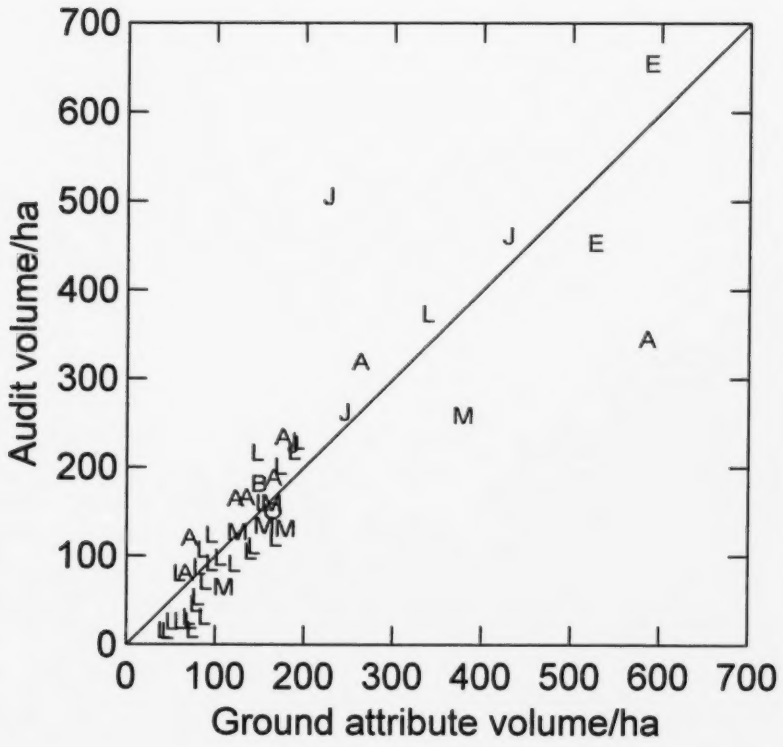
4. Paired T Test @ 95% for all sample polygons by map label GTG
   There were no significant differences within any of the GTGs.

5. Correlation @95%($\alpha = 0.05$) for all samples (n=49)
   Correlation co-efficient r = 0.880
   p - value for correlation co-efficient < 0.001
   .: correlation is significant

---

* Top height (and hence ground attribute volume) was not available for 1 sample. All statistics on this page are based on the 49 samples for which both an audit volume and a ground attribute volume was available.

Williams Lake TSA Inventory Audit Study #1: "Model Bias"
Audit Volume vs. Ground Attribute Volume (by GTG)
(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #1

Ground Attribute Volume (predicted in VDYP) vs. Inventory Volume (predicted in VDYP): "Attribute" Bias (n=49)*

1. Average volumes/ha and confidence interval @ 95%
(Utilization level : 12.5 cm + net merch. less decay only)

131 —— 168 ——206
Ground Attribute Volume (n=49)
(22.4% sampling error)

152 —— 190 ——228
Inventory Volume (n=49)
(19.9% sampling error)

2. Ratio Analysis : Ratio of Means @ 95% (n=49)

$$R = \frac{\text{average ground attribute volume (VDYP)}}{\text{average inventory volume (VDYP)}} = 0.89$$

1.0
↓
0.76 ——0.89——1.02

** The ratio indicates that there is no significant difference between the ground attribute volume predicted in the VDYP and the inventory volume predicted in the VDYP.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons (n=49)
mean difference = -21.39 m^3/ha
p - value for mean difference = 0.099
**since p - value > α, the difference is not significant*

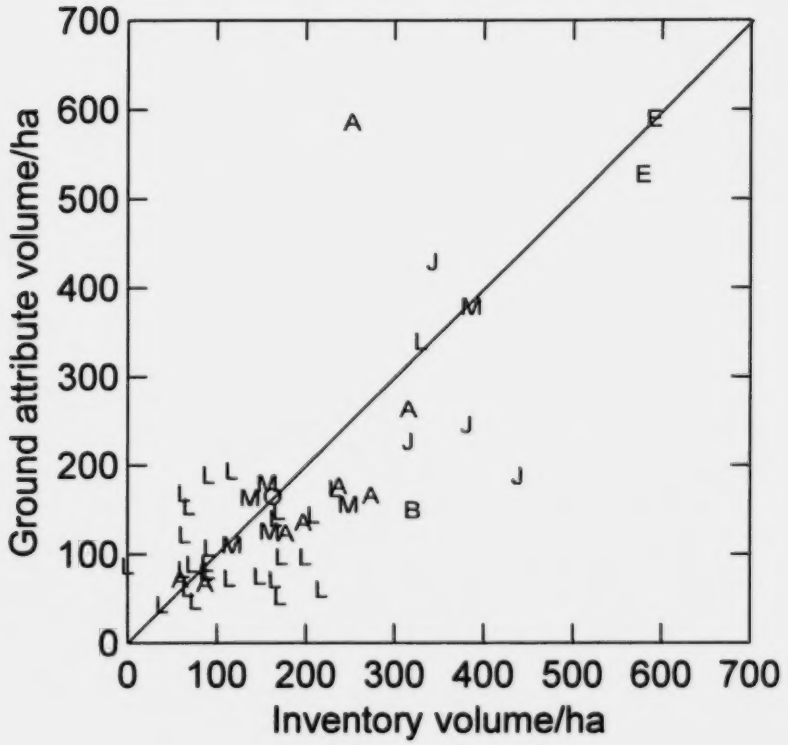
4. Paired T Test @ 95% for all sample polygons by map label GTG
There were no significant differences within any of the GTGs.

5. Correlation @95%($\alpha = 0.05$) for all samples
Correlation co-efficient r = 0.769
p - value for correlation co-efficient < 0.001
.: correlation is significant

---

* Top height (and hence ground attribute volume) was not available for 1 sample. All statistics on this page are based on the 49 samples for which both an inventory volume and a ground attribute volume was available.

Williams Lake TSA Inventory Audit Study #1: "Attribute Bias"
Ground Attribute Volume vs. Inventory Volume (by GTG)
(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #1

Audit (ground) height (m) vs. Inventory height (m) (n=49)*

1. Average heights and confidence interval @ 95%

17.1——18.9——20.7 Audit (ground) height (9.5% sampling error)

17.9——19.9——21.8 Inventory height (n=49) (9.9% sampling error)

2. Ratio Analysis : Ratio of Means @ 95%

$$R = \frac{\text{average audit height}}{\text{average inventory height}} = 0.95$$

1.0
↓

0.88——0.95——1.02

** The ratio indicates there is no significant difference between the audit height and the inventory height.*

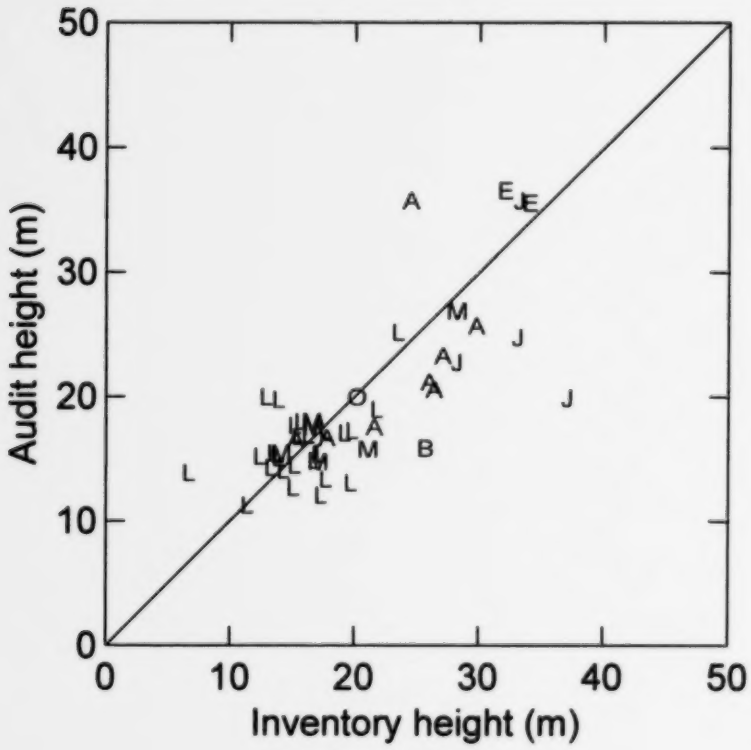
3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons (n=49)
mean difference = -1.00 m
p - value for mean difference = 0.142
**since p - value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were no significant differences within any of the GTGs.

5. Correlation @95%($\alpha = 0.05$) for all samples
Correlation co-efficient r = 0.750
p - value for correlation co-efficient < 0.001
.: correlation is significant

* There are 49 samples for which there are both inventory attributes (age and height) and valid ground top height and age data.

Williams Lake TSA Inventory Audit Study #1: Audit (ground) height vs. Inventory height by GTG



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #1

Audit (ground) age (yrs) vs. Inventory age (yrs) (n=49)*

1. Average ages and confidence interval @ 95%

109——————139——————169 Audit (ground) age (21.7% sampling error)

130——148——166 Inventory age (n=49) (12.1% sampling error)

2. Ratio Analysis : Ratio of Means @ 95%

$$R = \frac{\text{average audit age}}{\text{average inventory age}} = 0.94$$

1.0
↓

0.79——0.94——1.09

** The ratio indicates there is no significant difference between the audit age and the inventory age.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons
mean difference = -8.88 years
p - value for mean difference = 0.433
**since p - value > α, the difference is not significant*

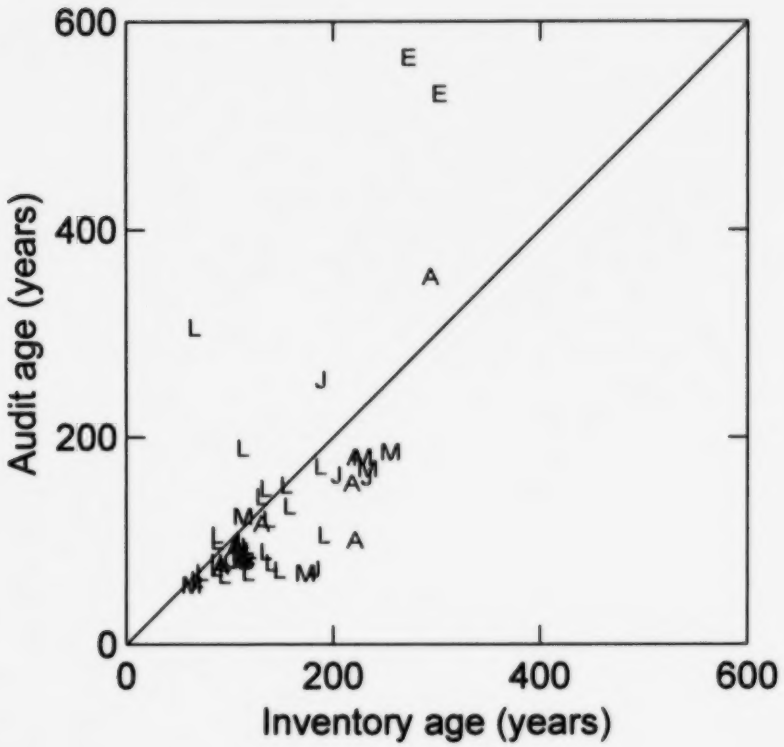
4. Paired T Test @ 95% for all sample polygons by map label GTG
There was a significant differences for GTG M.
(for GTG M: mean difference = -47.17 m; p - value = 0.043; n=6)

5. Correlation @95%($\alpha = 0.05$) for all samples
Correlation co-efficient r = 0.666
p - value for correlation co-efficient < 0.001
.: correlation is significant

---

* There are 49 samples for which there are both inventory attributes (age and height) and valid ground top height and age data.

Williams Lake TSA Inventory Audit Study #1: Audit (ground) age vs. Inventory age by GTG



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #1

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) (n=50)): Plots excluded that crew judged as "outside of polygon"

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Kozak/Tree Class 1,2)*

129——————169——————208 Audit Volume (23.3% sampling error)

153——————190——————227 Inventory Volume (map label attributes predicted in VDYP) (19.4% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.89$

1.0 ↓

0..76——————0.89——————1.01

* *Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the audit volume and the inventory volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons

mean difference = -21.32 m^3/ha

p - value for mean difference = 0.088

**since p-value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG

There were no significant differences within any of the GTGs.

5. Correlation @ 95% (α=0.05) for all samples

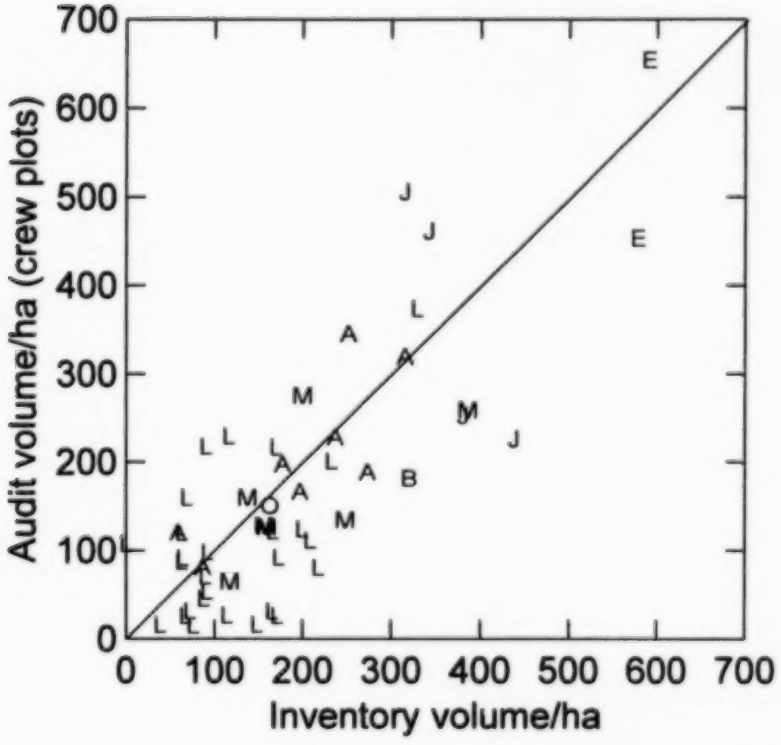
Correlation co-efficient r = 0.793

p value for correlation co-efficient < 0.001

∴ correlation is significant

Williams Lake TSA Inventory Audit Study #1 (plots excluded that crew judged as "outside of polygon"): Audit Volume vs. Inventory Volume (by GTG)

(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #1

Inventory Classification Assessment

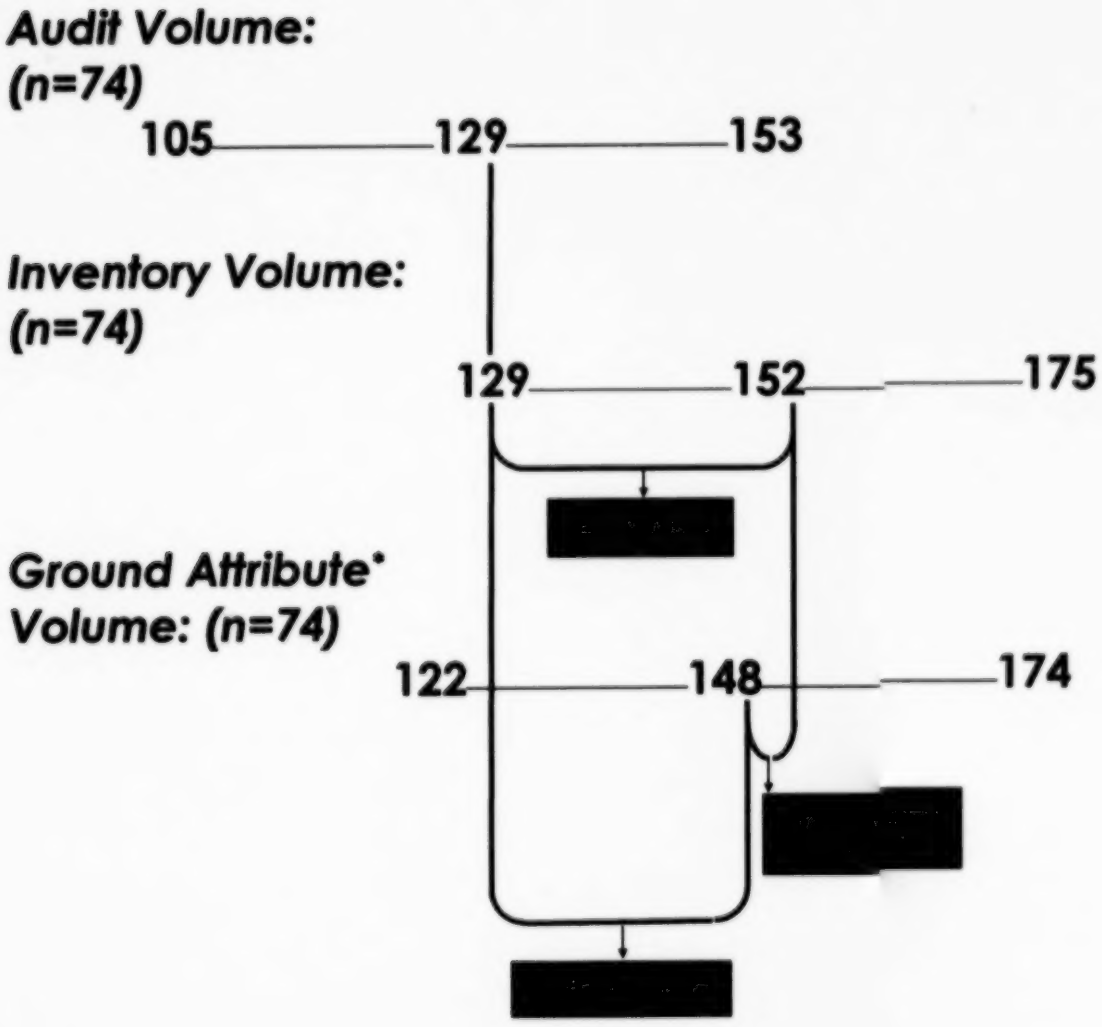
- **64%** of the growth type groups from the inventory (ie. map labels) matched the audit growth type groups.
- the growth type group distribution for the 50 inventory audit samples is as follows (the bold italic entries on the diagonal in the table indicate a GTG match between the audit and the inventory):

Audit GTG (rows)	***Inventory GTG (columns)***											
	A	B	C	E	H	I	J	L	M	N	O	*total*
A	***5***	0	0	0	0	0	0	0	0	0	0	5
B	1	***0***	0	0	0	0	0	0	0	0	0	1
C	2	0	***0***	0	0	0	0	2	0	0	0	4
E	0	1	0	***2***	0	0	0	0	0	0	0	3
H	0	0	0	0	***0***	0	1	0	0	0	1	2
I	0	0	0	0	0	***0***	1	0	0	0	0	1
J	0	0	0	0	0	0	***2***	0	0	0	0	2
L	0	0	0	0	0	0	0	***19***	3	0	0	22
M	0	0	0	0	0	0	0	4	***4***	0	0	8
N	0	0	0	0	0	0	0	2	0	***0***	0	2
O	0	0	0	0	0	0	0	0	0	0	***0***	0
total	8	1	0	2	0	0	4	27	7	0	1	**50**

Letter symbols correspond to GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Williams Lake TSA: Study #2



* "Ground attribute" volume is calculated from audit sample attributes (i.e. "ground" attributes: stock and stand table estimates of species composition and stocking, and ground-based averages of top height and age), along with crown closure taken from the original map label, using the VDYP yield prediction model. The difference between the ground attribute volume estimate and the audit volume estimate *approximates* the bias associated with the yield model. The difference between the ground attribute volume estimate and the inventory volume estimate *approximates* the bias associated with the inventory classification attributes. These two bias components comprise the *total bias* in the inventory.

Study #2

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) (n=74)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

105 ——— 129 ——— 153 Audit Volume (18.9% sampling error)

129 ——— 152 ——— 175 Inventory Volume (map label attributes predicted in VDYP) (15.4% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.85$

1.0 ↓

0.72 ——— 0.85 ——— 0.98

• *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the inventory volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons

mean difference = -23.004 m^3/ha
p - value for mean difference = 0.028
since p-value < α, the difference is significant

4. Paired T Test @ 95% for all sample polygons by map label GTG

There was a significant difference within GTGs C and L.
(for GTG C: mean difference = -94.500 m^3/ha; p-value=0.035; n=4
for GTG L: mean difference = -23.873 m^3/ha; p-value=0.029; n=45)

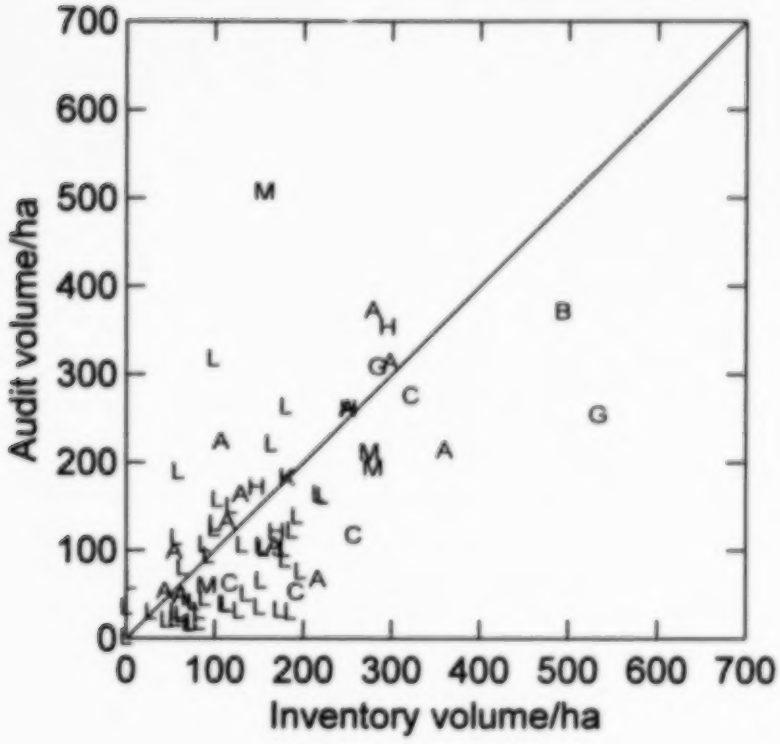
5. Correlation @ 95% (α=0.05) for all samples

Correlation co-efficient r = 0.636
p value for correlation co-efficient < 0.001
∴ correlation is significant

Williams Lake TSA Inventory Audit Study #2:

Audit Volume vs. Inventory Volume (by GTG)

(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #2

Audit Volume (Kozak) vs. Ground Attribute Volume (Predicted in VDYP): "Model Bias" (n=74)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

105 ——— 129 ——— 153

Audit Volume
(18.9% sampling error)

122 ——— 148 ——— 174

Ground Attribute Volume
(ground attributes predicted in VDYP)
(17.7% sampling error)

2. Ratio Analysis : Ratio of Means @ 95%

$R = \frac{\text{average audit volume}}{\text{average ground attribute volume}} = 0.87$

1.0
↓

0.78 ——— 0.87 ——— 0.97

- *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the ground attribute volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons

mean difference = -18.832 m^3/ha
p - value for mean difference = 0.012
since p-value < α, the difference is significant

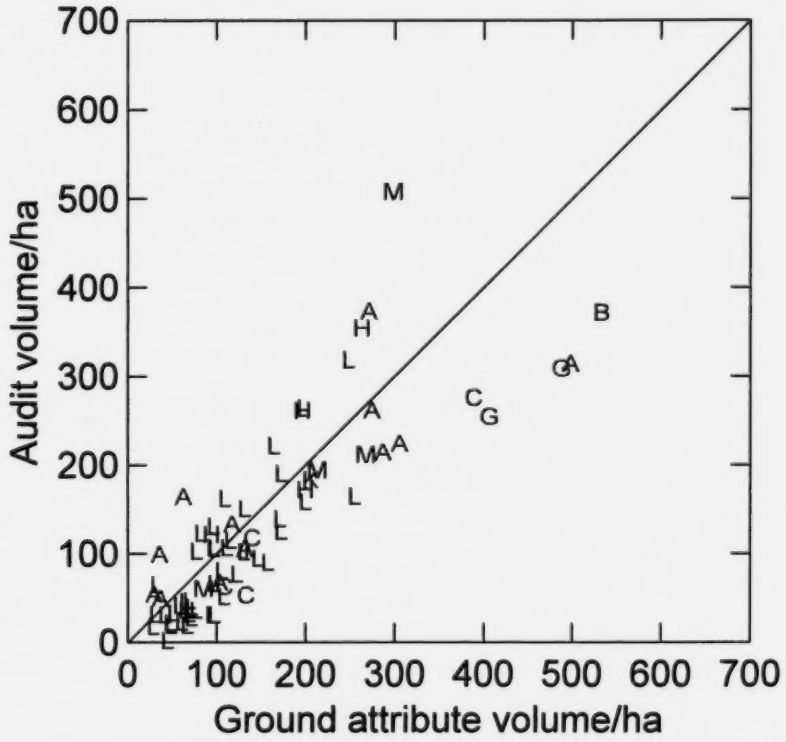
4. Paired T Test @ 95% for all sample polygons by map label GTG

There was a significant difference within GTGs C and L.
(for GTG C: mean difference = -65.825 m^3/ha; p-value=0.045; n=4
for GTG L: mean difference = -16.620 m^3/ha; p-value=0.005; n=45)

5. Correlation @ 95% (α= 0.05) for all samples

Correlation co-efficient r = 0.836
p value for correlation co-efficient < 0.001
∴ correlation is significant

Williams Lake TSA Inventory Audit Study #2: "Model Bias"
Audit Volume vs. Ground Attribute Volume (by GTG)
(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #2

Ground Attribute Volume vs. Inventory Volume: "Attribute Bias" (n=74)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

122——148——174

Ground Attribute Volume
(ground attributes predicted in VDYP)
(17.7% sampling error)

129——152——175 Inventory Volume
(map label attributes predicted in VDYP)
(15.4% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$R = \frac{\text{average ground attribute volume}}{\text{average inventory volume}} = 0.97$

1.0
↓

0.86——0.97——1.08

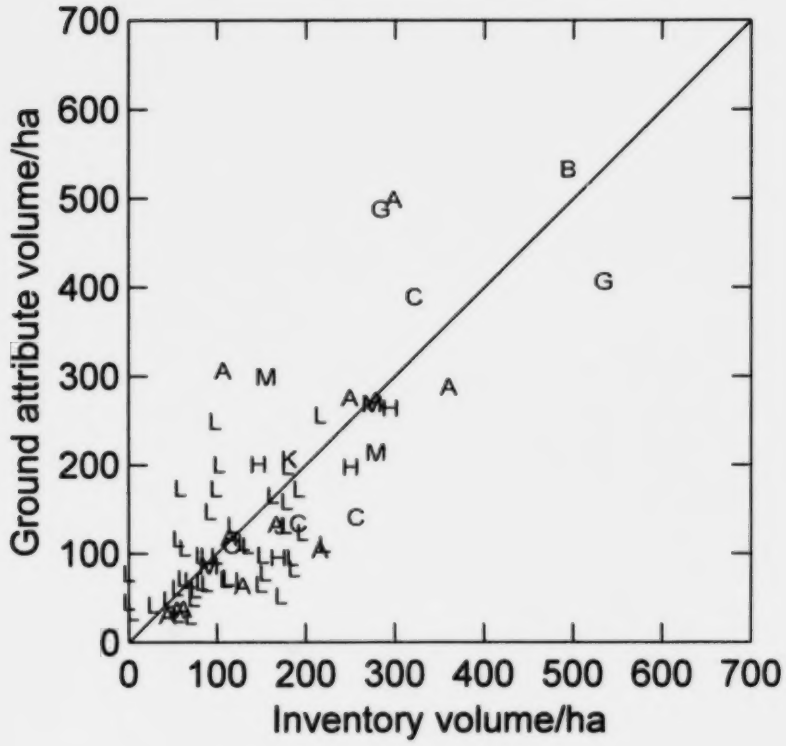
* *Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the ground attribute volume and the inventory volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons
mean difference = -4.172 m^3/ha
p - value for mean difference = 0.620
**since p-value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were no significant differences within any of the GTGs.

5. Correlation @ 95% (α=0.05) for all samples
Correlation co-efficient r = 0.779
p value for correlation co-efficient < 0.001
∴ correlation is significant

Williams Lake TSA Inventory Audit Study #2: "Attribute Bias"
Ground Attribute Volume vs. Inventory Volume (by GTG)
(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #2

Audit (ground) height (m) vs. Inventory height (m) (n=74)

1. Average heights and confidence interval @ 95%

16.7——18.1——19.5 Audit (ground) height (7.9% sampling error)

17.0——18.4——19.9 Inventory height (7.7% sampling error)

2. Ratio Analysis : Ratio of Means @ 95%

$$R = \frac{\text{average audit height}}{\text{average inventory height}} = 0.98$$

1.0
↓

0.94——0.98——1.03

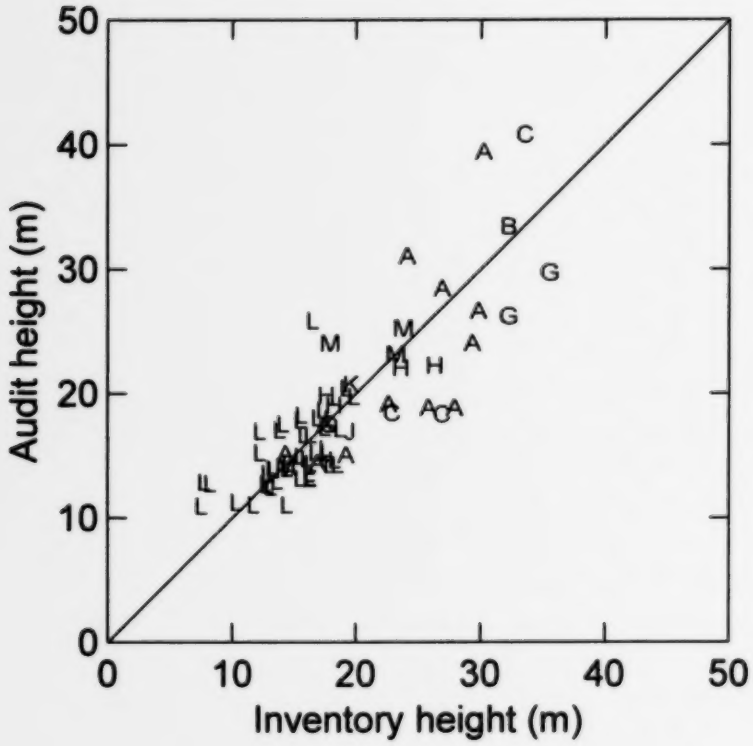
** The ratio indicates there is no significant difference between the audit height and the inventory height.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons
mean difference = -0.330 m
p - value for mean difference = 0.436
**since p - value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There was a significant difference within GTG G.
(for GTG G: mean difference = -5.9 m; p - value = 0.011; n=2)

5. Correlation @95%($\alpha = 0.05$) for all samples
Correlation co-efficient r = 0.826
p - value for correlation co-efficient < 0.001
.: correlation is significant

Williams Lake TSA Inventory Audit Study #2: Audit (ground) height vs. Inventory height by GTG



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #2

Audit (ground) age (yrs) vs. Inventory age (yrs) (n=74)

1. Average ages and confidence interval @ 95%

111——124——136 Audit (ground) age (9.9% sampling error)

120——132——145 Inventory age (9.7% sampling error)

2. Ratio Analysis : Ratio of Means @ 95%

$$R = \frac{\text{average audit age}}{\text{average inventory age}} = 0.93$$

1.0 ↓

0.85——0.93——1.01

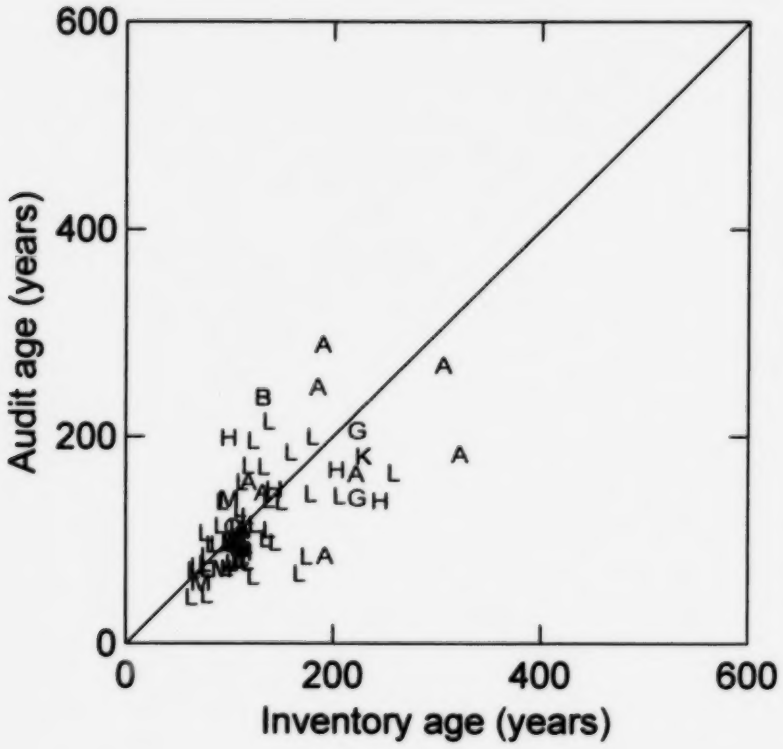
** The ratio indicates there is no significant difference between the audit age and the inventory age.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons
mean difference = -8.750 years
p - value for mean difference = 0.115
**since p - value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were no significant differences within any of the GTGs.

5. Correlation @95%($\alpha = 0.05$) for all samples
Correlation co-efficient r = 0.618
p - value for correlation co-efficient < 0.001
.: correlation is significant

Williams Lake TSA Inventory Audit Study #2: Audit (ground) age vs. Inventory age by GTG



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #2

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) (n=744): Plots excluded that crew judged as "outside of polygon"

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

103 — 128 — 152 Audit Volume (19.1% sampling error)

129 — 152 — 175 Inventory Volume (map label attributes predicted in VDYP) (15.4% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.84$$

1.0 ↓

0.72 — 0.84 — 0.97

- *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the inventory volume.*

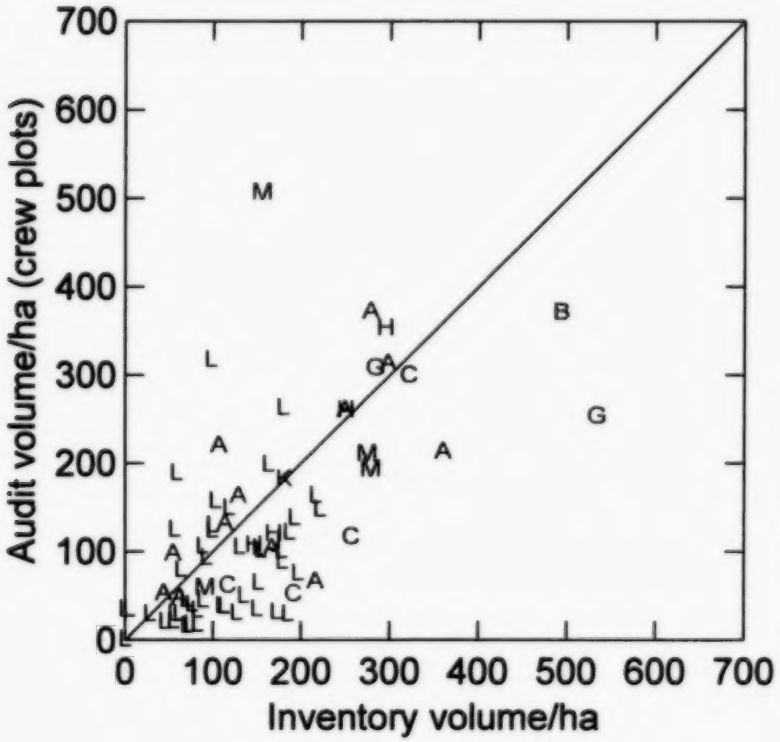
3. Paired T Test @ 95% (α=0.05) for all sample polygons
   mean difference = -24.092 m^3/ha
   p - value for mean difference = 0.021
   since p-value < α, the difference is significant

4. Paired T Test @ 95% for all sample polygons by map label GTG
   There was a significant difference within GTG L.
   (for GTG L: mean difference = -24.882; p-value=0.022; n=45)

5. Correlation @ 95% (α=0.05) for all samples
   Correlation co-efficient r = 0.642
   p value for correlation co-efficient < 0.001
   ∴ correlation is significant

Williams Lake TSA Inventory Audit Study #2 (plots excluded that crew judged as "outside of polygon"): Audit Volume vs. Inventory Volume (by GTG)

(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy, CwPw, CwPl, CwDecid, CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd, PlPy, PlL, PlPw, PlS, PlB, PlH, PlCw, PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study #2

Inventory Classification Assessment

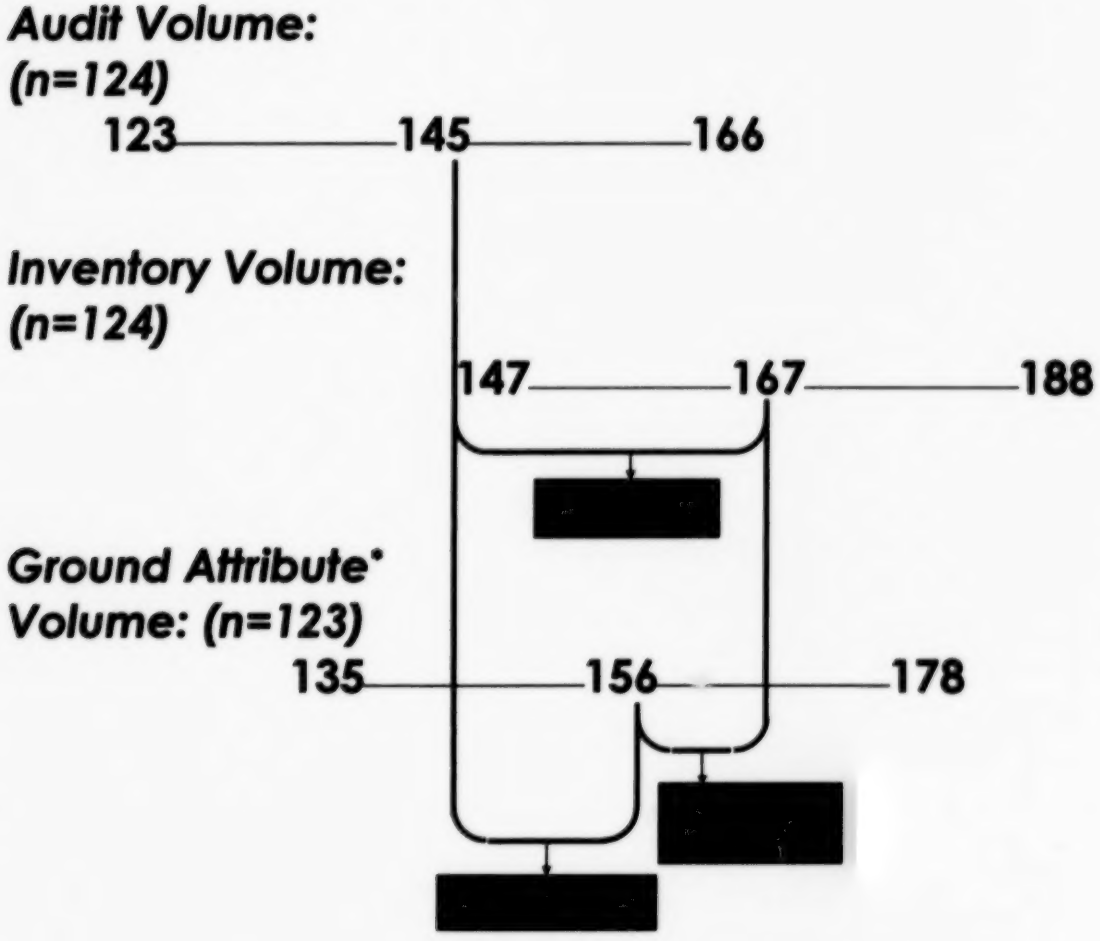
- **80%** of the growth type groups from the inventory (ie. map labels) matched the audit growth type groups.
- the growth type group distribution for the 74 inventory audit samples is as follows (the bold italic entries on the diagonal in the table indicate a GTG match between the audit and the inventory):

Audit GTG	***Inventory GTG (columns)***												
(rows)	A	B	C	F	G	H	I	J	K	L	M	O	*total*
A	***9***	0	0	0	0	0	0	0	0	0	0	0	9
B	1	***1***	1	0	0	0	0	0	0	0	0	0	3
C	0	0	***3***	0	0	0	0	0	0	0	0	0	3
F	0	0	0	***0***	1	0	0	0	0	0	0	0	1
G	0	0	0	0	***1***	0	0	0	0	0	0	0	1
H	0	0	0	0	0	***4***	0	0	0	0	0	0	4
I	0	0	0	0	0	0	***0***	0	0	1	0	0	1
J	1	0	0	0	0	0	0	***1***	0	0	0	0	2
K	0	0	0	0	0	0	0	0	***1***	0	0	0	1
L	0	0	0	0	0	0	0	0	0	***37***	1	0	38
M	1	0	0	0	0	0	0	0	0	7	***2***	0	10
O	0	0	0	0	0	0	0	0	0	0	1	***0***	1
total	12	1	4	0	2	4	0	1	1	45	4	0	**74**

Letter symbols correspond to GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Williams Lake TSA: Study 1 & 2 Combined



* "Ground attribute" volume is calculated from audit sample attributes (i.e. "ground"" attributes: stock and stand table estimates of species composition and stocking, and ground-based averagees of top height and age), along with crown closure taken from the original map label, using the VDYP yyield prediction model. The difference between the ground attribute volume estimate and the audit volume eestimate *approximates* the bias associated with the yield model. The difference between the ground attributee volume estimate and the inventory volume estimate *approximates* the bias associated with the inventory cclassification attributes. These two bias components comprise the *total bias* in the inventory. Note that top heeight and age was not available for sample #108 hence mean ground attribute volume is based on 123 sampples.

Study 1 & 2 Combined

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) (n=124)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

123 ——— 145 ——— 166 Audit Volume (14.8% sampling error)

147 ——— 167 ——— 188 Inventory Volume (map label attributes predicted in VDYP) (12.2% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.87$

1.0 ↓

0.78 ——— 0.87 ——— 0.95

* *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the inventory volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons

mean difference = -22.563 m^3/ha
p - value for mean difference = 0.005
**since p-value < α, the difference is significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG

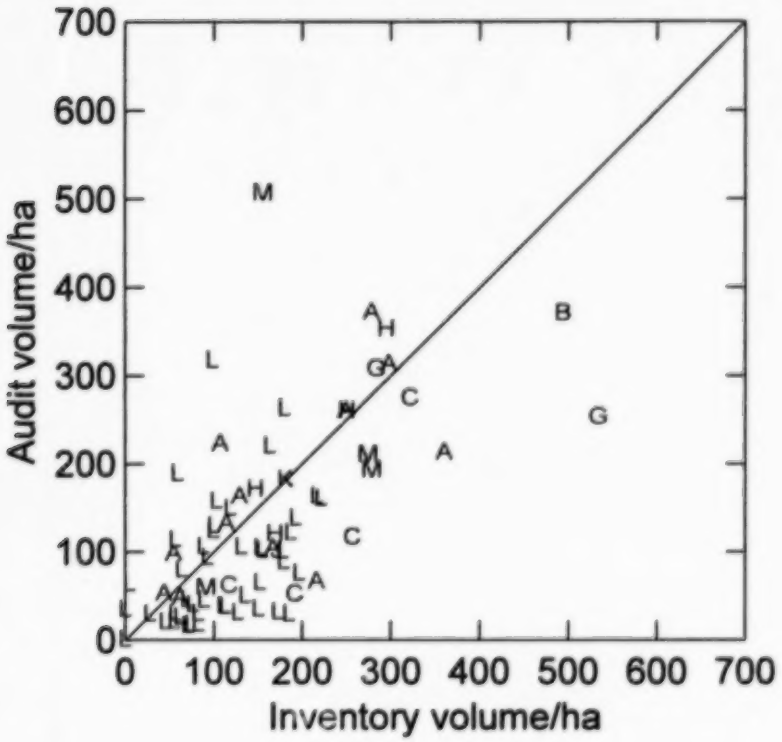
There was a significant difference within GTGs B, C and L.
(for GTG B: mean difference = -130.500 m^3/ha; p-value=0.042; n=2
for GTG C: mean difference = -94.500 m^3/ha; p-value=0.035; n=4
for GTG L: mean difference = -23.496 m^3/ha; p-value=0.009; n=72)

5. Correlation @ 95% (α=0.05) for all samples

Correlation co-efficient r = 0.728
p value for correlation co-efficient < 0.001
.: correlation is significant

Williams Lake TSA Inventory Audit Study 1 & 2 Combined: Audit Volume vs. Inventory Volume (by GTG)

(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study 1 & 2 Combined

Audit Volume (Kozak) vs. Ground Attribute Volume (Predicted in VDYP): "Model Bias" (n=123)*

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

122 ——— 144 ——— 165 Audit Volume (15.0% sampling error)

135 ——— 156 ——— 178 Ground Attribute Volume (ground attributes predicted in VDYP) (13.8% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$R = \frac{\text{average audit volume}}{\text{average ground attribute volume}} = 0.92$

1.0 ↓

0.85 ——— 0.92 ——— 0.99

* *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the ground attribute volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons

mean difference = -12.319 m^3/ha
p - value for mean difference = 0.037
since p-value < α, the difference is significant

4. Paired T Test @ 95% for all sample polygons by map label GTG

There was a significant difference within GTGs C and L.
(for GTG C: mean difference = -65.825 m^3/ha; p-value=0.045; n=4
for GTG L: mean difference = -14.376 m^3/ha; p-value=0.001; n=72)

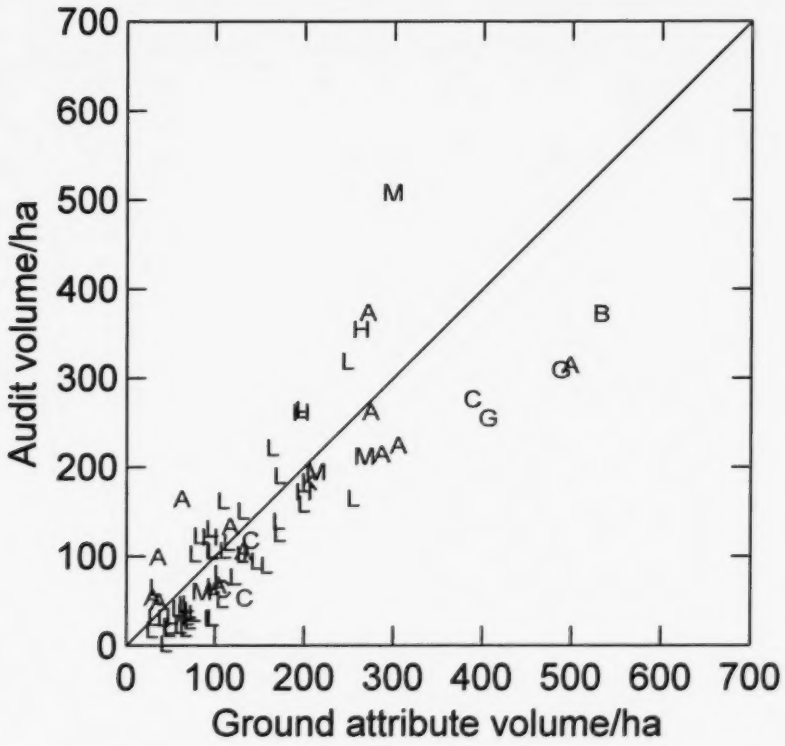
5. Correlation @ 95% (α=0.05) for all samples

Correlation co-efficient r = 0.856
p value for correlation co-efficient < 0.001
∴ correlation is significant

---

* Top height (and hence ground attribute volume) was not available for 1 sample. All statistics on this page are based on the 123 samples for which both an audit volume and a ground attribute volume was available.

Williams Lake TSA Inventory Audit Study 1 & 2 Combined:
"Model Bias"
Audit Volume vs. Ground Attribute Volume (by GTG)
(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study 1 & 2 Combined

Ground Attribute Volume vs. Inventory Volume: "Attribute Bias" (n=123)*

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

135——————156——————178 Ground Attribute Volume
(ground attributes predicted in VDYP)
(13.8% sampling error)

147——————167——————188 Inventory Volume
(map label attributes predicted in VDYP)
(12.3% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$$R = \frac{\text{average ground attribute volume}}{\text{average inventory volume}} = 0.93$$

1.0
↓

0.85——————0.93——————1.02

* *Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the ground attribute volume and the inventory volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons
mean difference = -11.031 m^3/ha
p - value for mean difference = 0.126
**since p-value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were no significant differences within any of the GTGs.

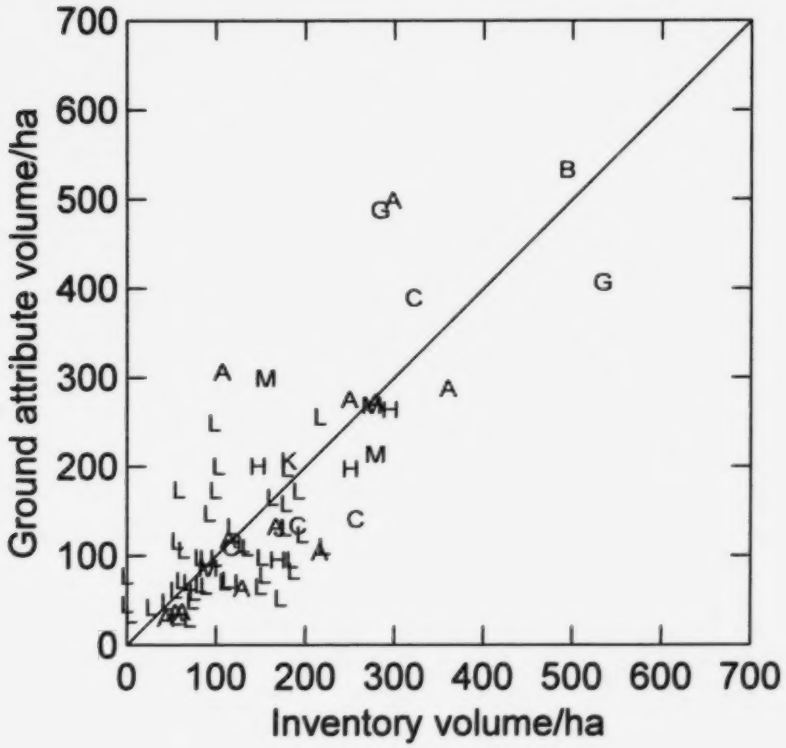
5. Correlation @ 95% (α=0.05) for all samples
Correlation co-efficient r = 0.774
p value for correlation co-efficient < 0.001
.: correlation is significant

---

* Top height (and hence ground attribute volume) was not available for 1 sample. All statistics on this page are based on the 123 samples for which both an inventory volume and a ground attribute volume was available.

Williams Lake TSA Inventory Audit Study 1 & 2 Combined: "Attribute Bias" Ground Attribute Volume vs. Inventory Volume (by GTG)

(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study 1 & 2 Combined

Audit (ground) height (m) vs. Inventory height (m) (n=123)*

1. Average heights and confidence interval @ 95%

17.3——18.4——19.5 Audit (ground) height (6.0% sampling error)

17.8——19.0——20.1 Inventory height (6.0% sampling error)

2. Ratio Analysis : Ratio of Means @ 95%

$$R = \frac{\text{average audit height}}{\text{average inventory height}} = 0.97$$

1.0
↓
0.93——0.97——1.01

** The ratio indicates there is no significant difference between the audit height and the inventory height.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons
mean difference = -0.596 m
p - value for mean difference = 0.107
**since p - value > α, the difference is not significant*

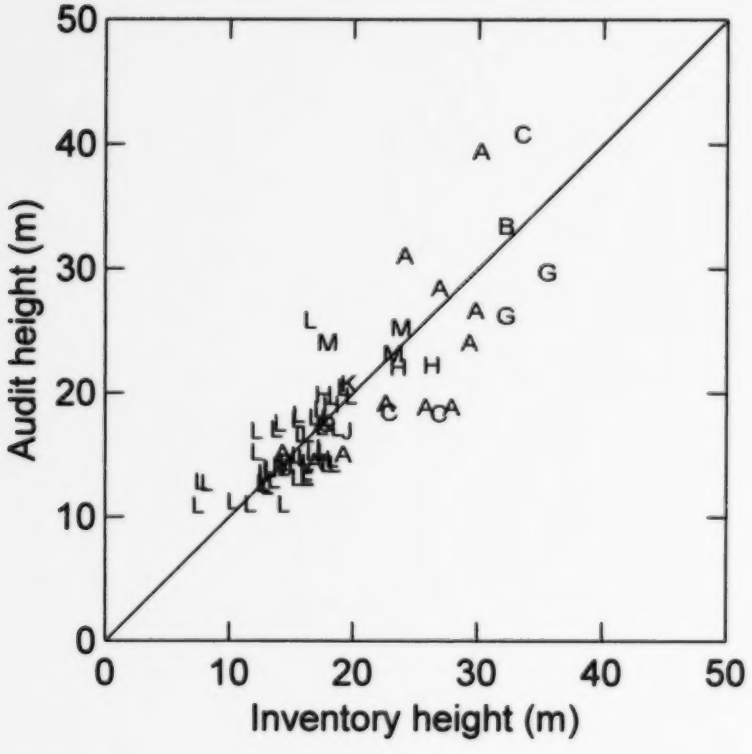
4. Paired T Test @ 95% for all sample polygons by map label GTG
There were significant differences within GTG G.
(for GTG G: mean difference = -5.9 m; p - value = 0.011; n=2)

5. Correlation @95%($\alpha = 0.05$) for all samples
Correlation co-efficient r = 0.792
p - value for correlation co-efficient < 0.001
∴ correlation is significant

---

* There are 123 samples for which there are both inventory attributes (age and height) and valid ground top height and age data.

Williams Lake TSA Inventory Audit Study 1 & 2 Combined: Audit (ground) height vs. Inventory height by GTG



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study 1 & 2 Combined

Audit (ground) age (yrs) vs. Inventory age (yrs) (n=123)*

1. Average ages and confidence interval @ 95%

116——130——144 Audit (ground) age (10.7% sampling error)

128——138——149 Inventory age (7.5% sampling error)

2. Ratio Analysis : Ratio of Means @ 95%

$$R = \frac{\text{average audit age}}{\text{average inventory age}} = 0.94$$

1.0
↓

0.86——0.94——1.02

** The ratio indicates there is no significant difference between the audit age and the inventory age.*

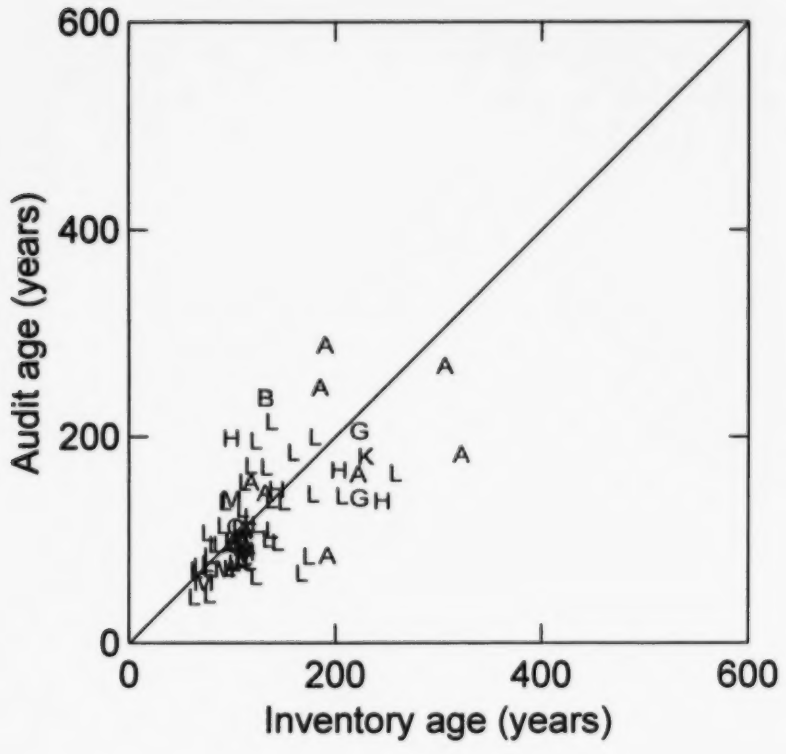
3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons
mean difference = -8.801 years
p - value for mean difference = 0.114
**since p - value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were significant differences within GTG M.
(for GTG M: mean difference = -30.30 years; p - value = 0.050; n=10)

5. Correlation @95%($\alpha = 0.05$) for all samples
Correlation co-efficient r = 0.627
p - value for correlation co-efficient < 0.001
.: correlation is significant

* There are 123 samples for which there are both inventory attributes (age and height) and valid ground top height and age data.

Williams Lake TSA Inventory Audit Study 1 & 2 Combined: Audit (ground) age vs. Inventory age by GTG



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study 1 & 2 Combined

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) (n^2=124): Plots excluded that crew judged as "outside of polygon"

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 12.5 cm + net merch. less decay only/Tree Class 1,2)*

123 ——— 144 ——— 166 Audit Volume (14.9% sampling error)

147 ——— 167 ——— 188 Inventory Volume (map label attributes predicted in VDYP) (12.2% sampling error)

2. Ratio Analysis : Ratio of Means @95%

$$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.86$$

1.0 ↓

0.77 ——— 086 ——— 0.95

* *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the inventory volume.*

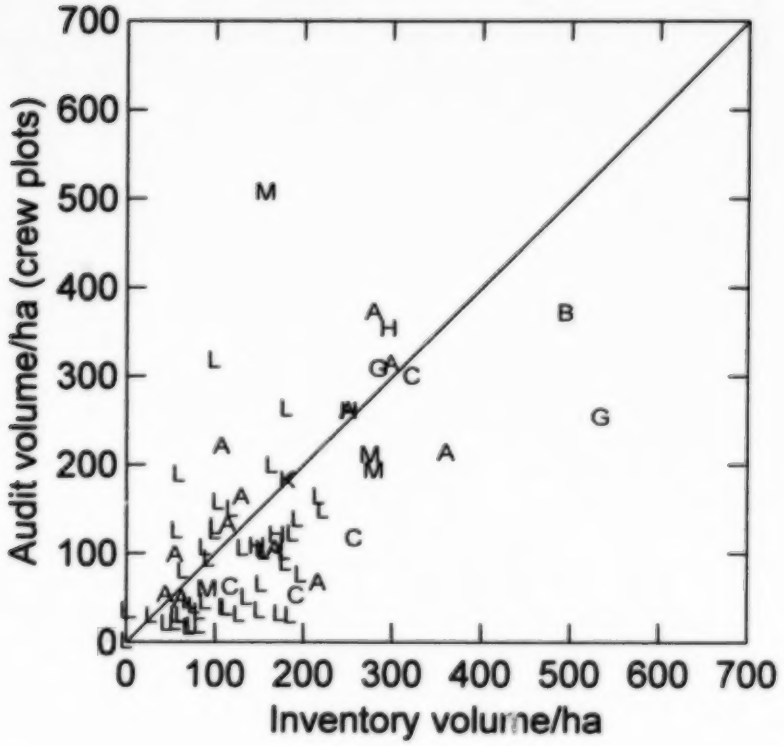
3. Paired T Test @ 95% (α=0.05) for all sample polygons
mean difference = -22.976 m^3/ha
p - value for mean difference = 0.004
**since p-value < α, the difference is significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were significant differences within GTGs B & L.
(for GTG B: mean difference = -130.500; p-value=0.042; n=2
for GTG L: mean difference = -23.897; p-value=0.007; n=72)

5. Correlation @ 95% (α=0.05) for all samples
Correlation co-efficient r = 0.730
p value for correlation co-efficient < 0.001
.: correlation is significant

Williams Lake TSA Inventory Audit Study 1 & 2 Combined (plots excluded that crew judged as "outside of polygon"): Audit Volume vs. Inventory Volume (by GTG)

(Tree Class 1 & 2, less decay only, 12.5cm + dbh)



Letter symbols correspond to map label GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*

Study 1 & 2 Combined

Inventory Classification Assessment

- **73%** of the growth type groups from the inventory (ie. map labels) matched the audit growth type groups.
- the growth type group distribution for the 124 inventory audit samples is as follows (the bold italic entries on the diagonal in the table indicate a GTG match between the audit and the inventory):

Audit GTG (rows)	Inventory GTG (columns)														
	A	B	C	E	F	G	H	I	J	K	L	M	N	O	total
A	***14***	0	0	0	0	0	0	0	0	0	0	0	0	0	14
B	2	***1***	1	0	0	0	0	0	0	0	0	0	0	0	4
C	2	0	***3***	0	0	0	0	0	0	0	2	0	0	0	7
E	0	1	0	***2***	0	0	0	0	0	0	0	0	0	0	3
F	0	0	0	0	***0***	1	0	0	0	0	0	0	0	0	1
G	0	0	0	0	0	***1***	0	0	0	0	0	0	0	0	1
H	0	0	0	0	0	0	***4***	0	1	0	0	0	0	1	6
I	0	0	0	0	0	0	0	***0***	1	0	1	0	0	0	2
J	1	0	0	0	0	0	0	0	***3***	0	0	0	0	0	4
K	0	0	0	0	0	0	0	0	0	***1***	0	0	0	0	1
L	0	0	0	0	0	0	0	0	0	0	***56***	4	0	0	60
M	1	0	0	0	0	0	0	0	0	0	11	***6***	0	0	18
N	0	0	0	0	0	0	0	0	0	0	2	0	***0***	0	2
O	0	0	0	0	0	0	0	0	0	0	0	1	0	***0***	1
total	20	2	4	2	0	2	4	0	5	1	72	11	0	1	**124**

Letter symbols correspond to GTG's as follows:

A	*pure Fd, FdDecid.*	I	*pure S*
B	*FdCw, FdYc, FdH, FdS*	J	*SFd, SL, SPw, SPy, SH, SCw, SYc, SB*
C	*FdPl, FdPy, Py*	K	*SPl, SDecid.*
E	*Cw or Yc, CwFd, CwL, CwPy,CwPw,CwPl, CwDecid,CwH*	L	*Pl or Pa*
F	*H, HDecid.*	M	*PlFd,PlPy,PlL,PlPw,PlS,PlB,PlH,PlCw,PlYc*
G	*HFd, HL, HPy, HPw, HPl, HCw, HB, HS*	N	*PlDecid.*
H	*B, BH, BS, BFd, BPw, BPl, BL, BPy, BDecid.*	O	*DConif, ATConif*